

Dobrý den

Ne-like Ar Soft X-ray Laser and Focusing of EUV Light

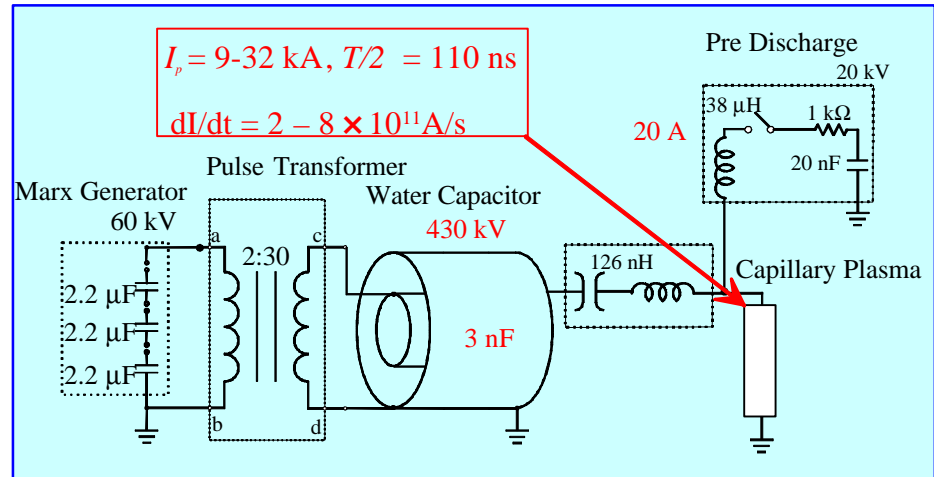
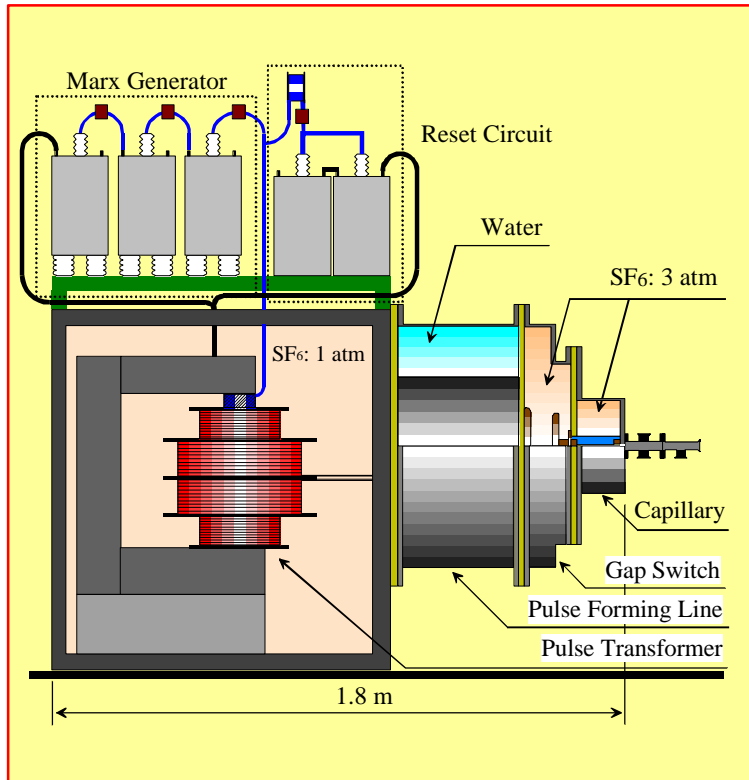
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- **Experimental Setup**
 - **Capillary discharge soft X-ray laser**
- **Experimental Results**
 - **Lasing properties – Gain characteristics**
 - **Parameter region – Current, Pressure**
 - **Effect of predischARGE, Contamination**
 - **Focusing of EUV light by Wolter mirror**
- **Summary**

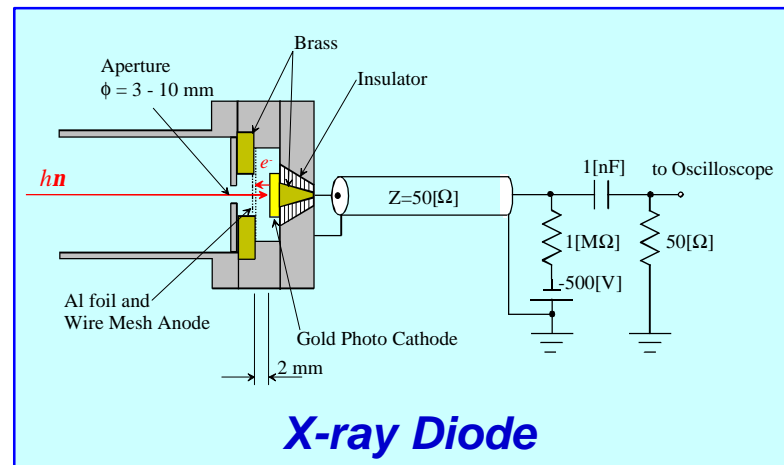
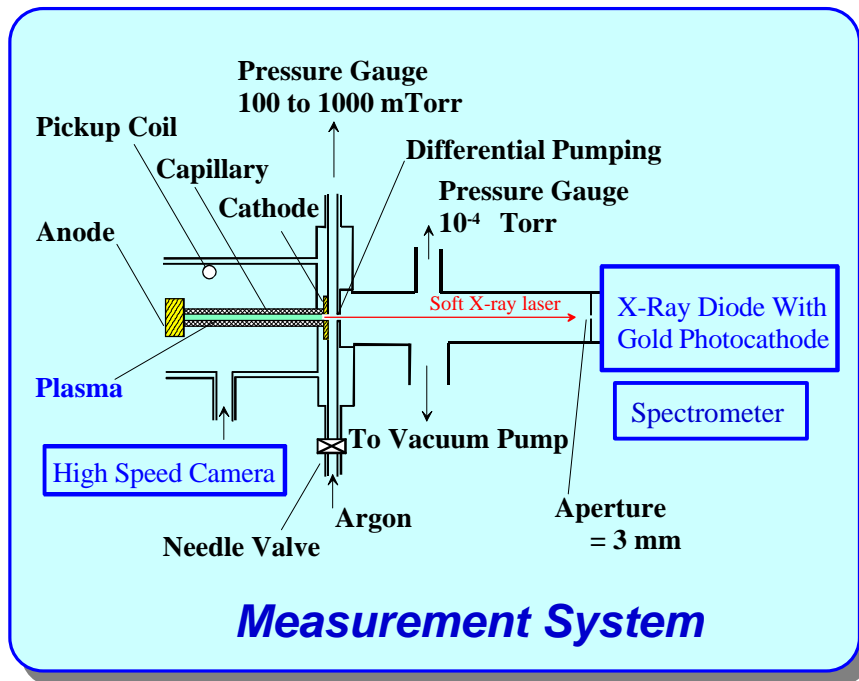
- **Construction of compact, high-power, short-wavelength X-ray laser**
 - **Application**
 - High rep-rate, compact X-ray laser : Metrology
 - Short wavelength : Diagnostics of high density plasma, X-ray microscope, etc.
 - **Property of soft X-ray laser**
 - Gain length product
 - Improvement of ECE : plasma dynamics, lasing physics
- **Focusing of EUV light by Wolter mirror**
 - **Simple deflection No aberration**

Experimental Device



Dimension of the Capillary
Inner diameter : 3, 4 mm
Length : 150, 200, 350mm

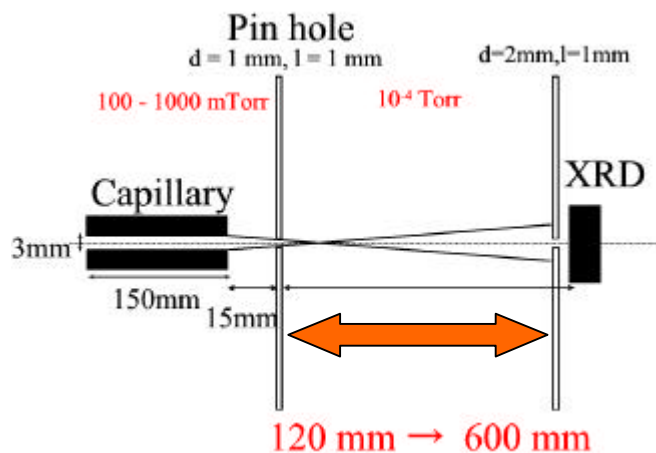
Setup of XRD Measurement System



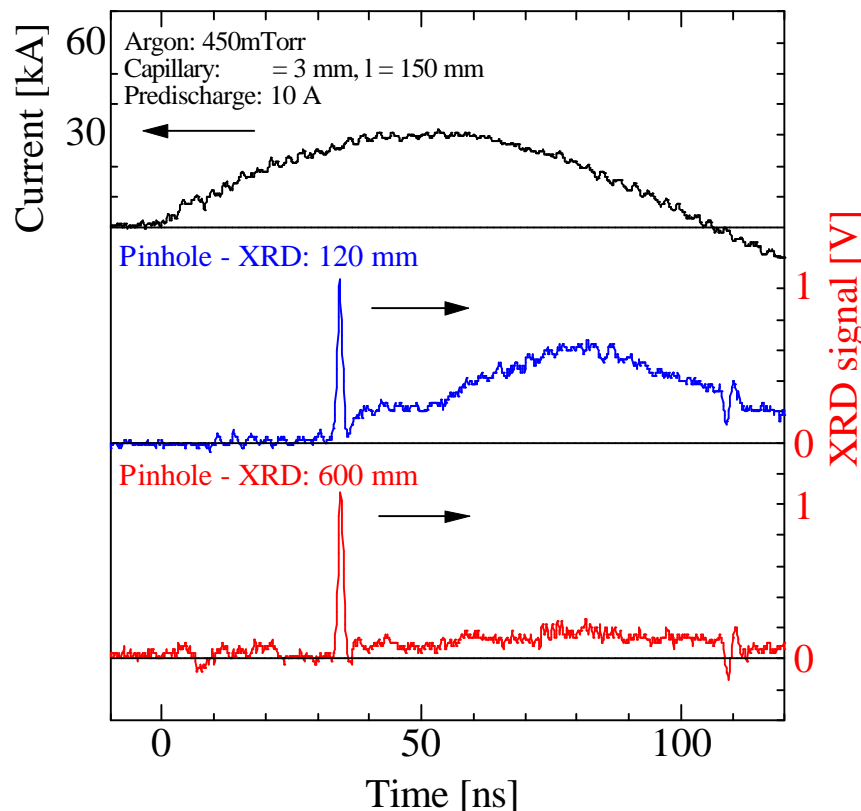
Aluminum foil filter of
0.8 or 2 μ m thick is used.

Discharge condition

- Capillary length : 150 mm,
diameter : 3 mm
- Filling Ar pressure : 450 mTorr
- Preionization current : 10 A

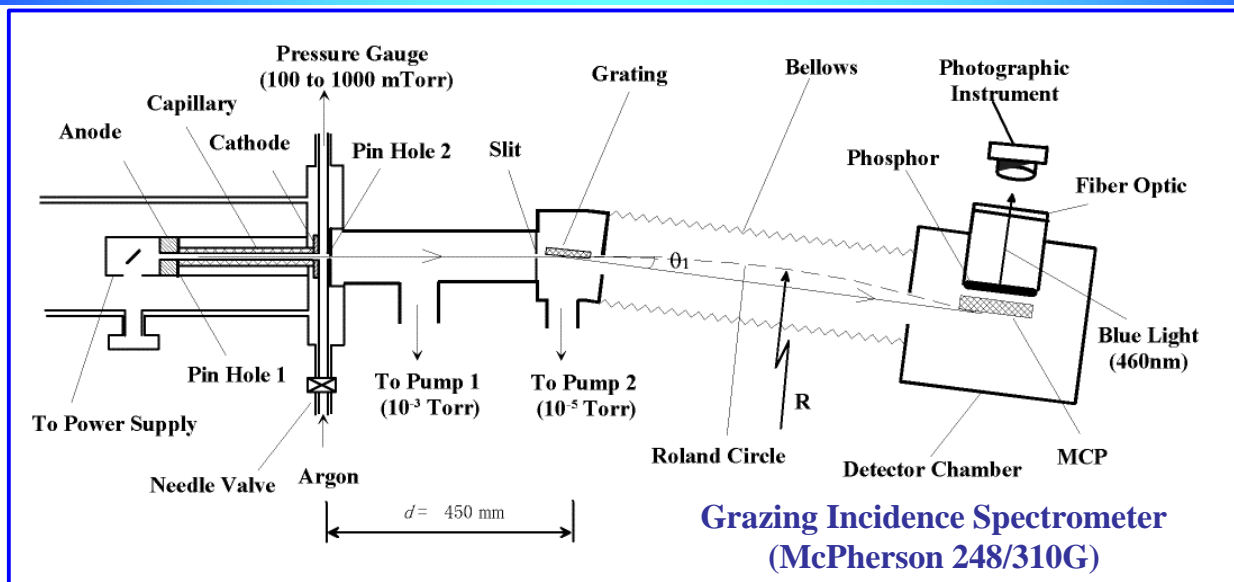


To confirm the directivity of laser,
the distance from the capillary to
the XRD is changed from 120mm
to 600mm



**XRD output dependence on distance
between capillary and detector**

Spectroscopic Measurement



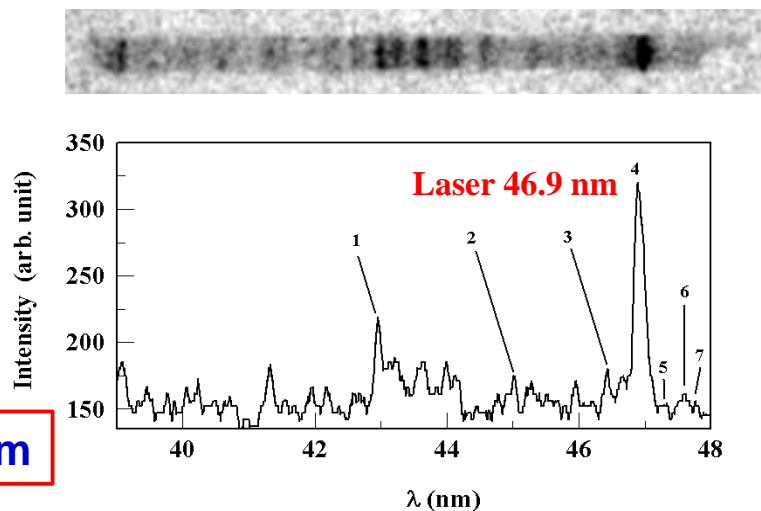
Discharge condition

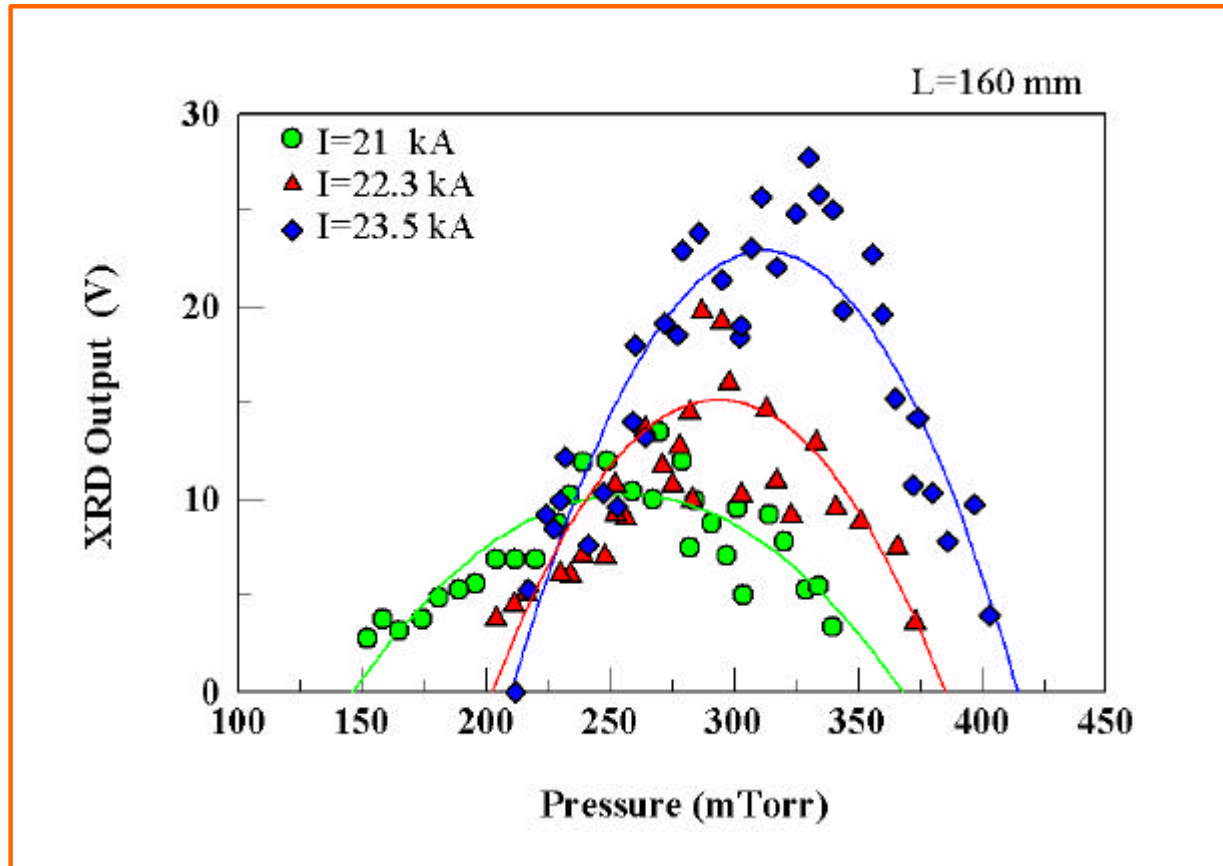
Capillary : 3, $l = 150$ mm

$I = 22$ kA

$p = 300$ mTorr

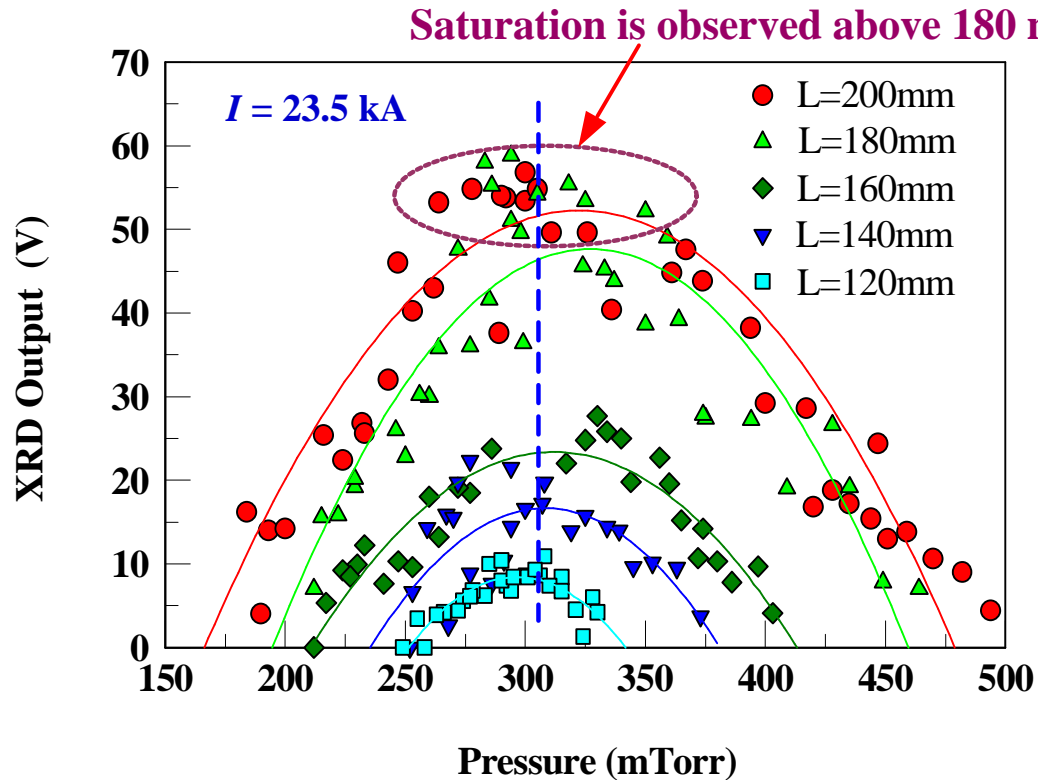
Measured spectrum





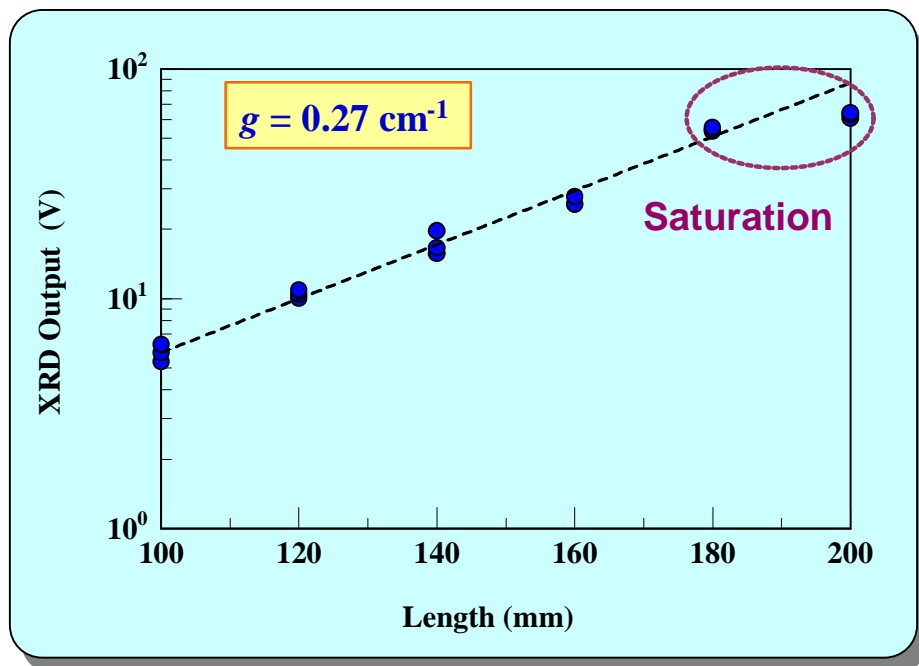
The XRD output increases by more than 100%, by increasing only 10 % of the discharge current. This indicates that the laser amplification is very sensitive to the discharge current.

Output Dependence on Plasma Length

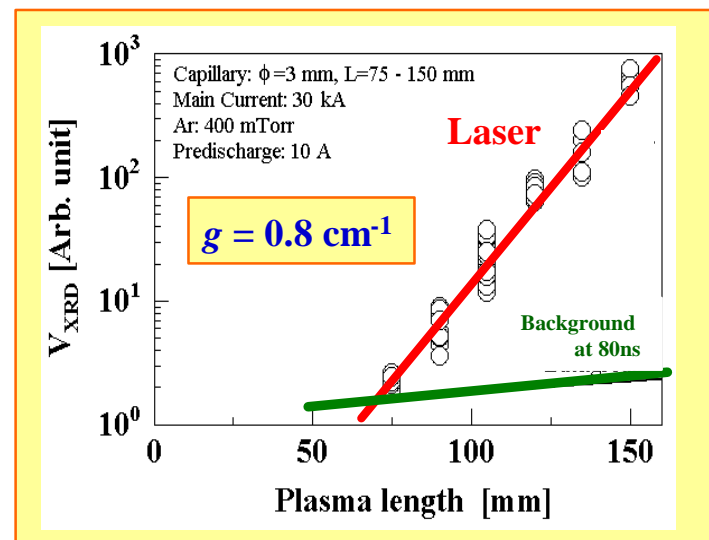


Gain-Length Product

$I = 23.5 \text{ kA}$
 $p = 300 \text{ mTorr Ar}$

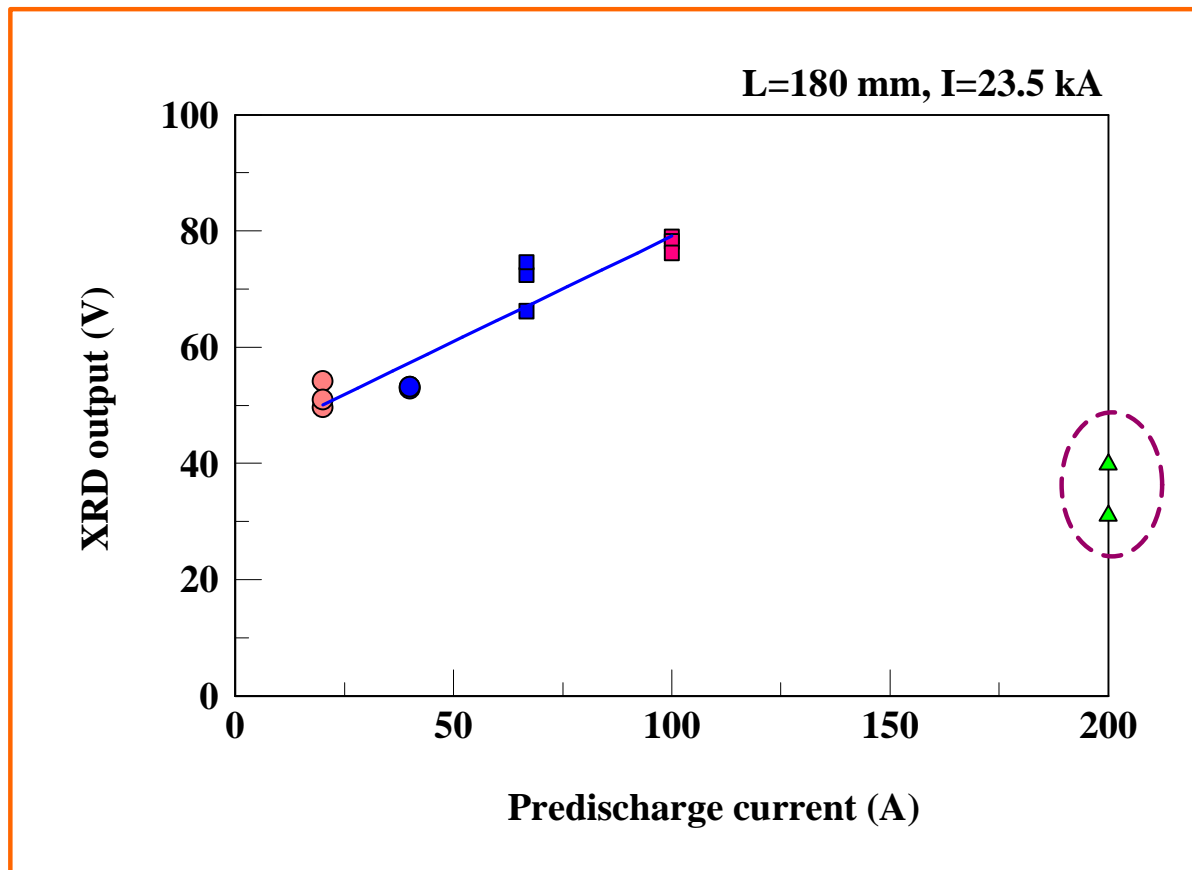


$I = 30 \text{ kA}$
 $p = 400 \text{ mTorr Ar}$



Maximum gain-length product gl of 12 ($g = 0.8 \text{ cm}^{-1}$) and Laser output energy of 5 - 6 μJ are obtained.

Dependence of XRD Output on Predischarge Current



Contamination of Capillary

After a few 100 shots, laser output is gradually decreasing.

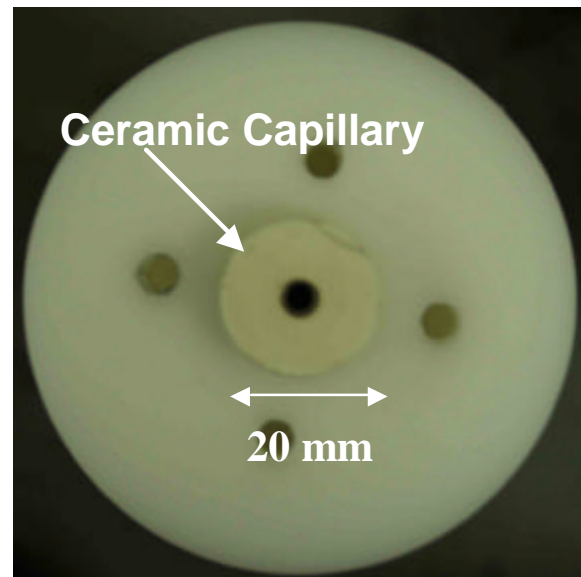


Black thin film is found on the inner wall of capillary, which may be caused by the deposition of electrode material (Molybdenum).

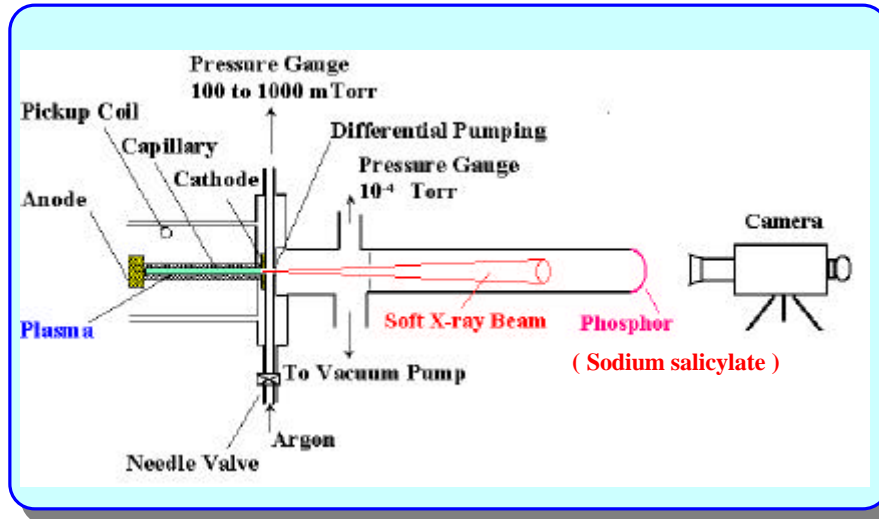


After treatment with nitric acid to remove the film, the laser output recovers the initial power.

Photo of capillary after a few 100 shots

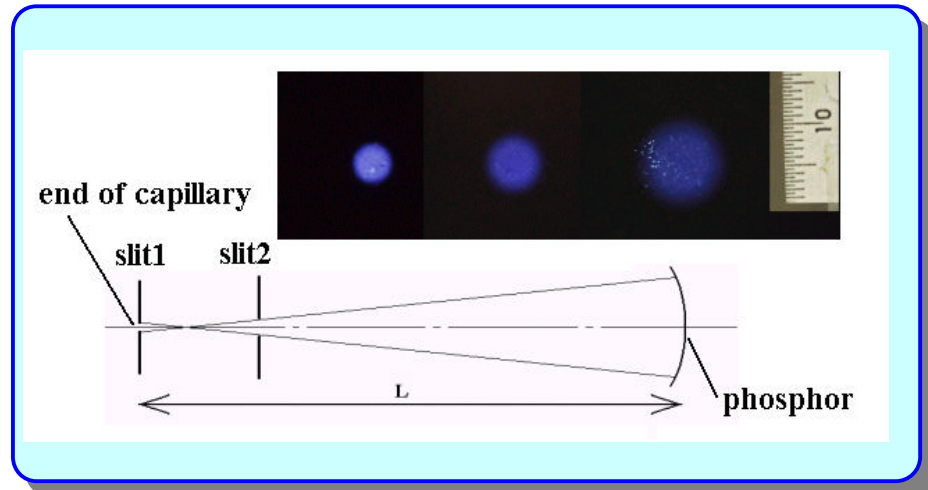


Analysis of contaminants is planned.



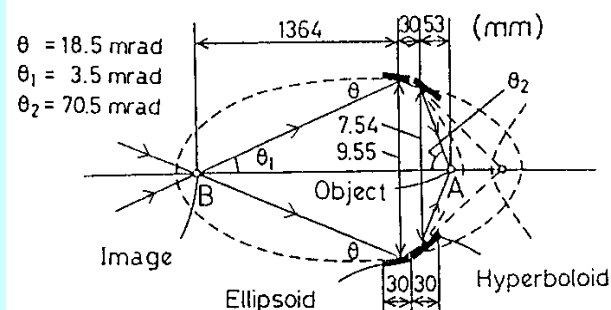
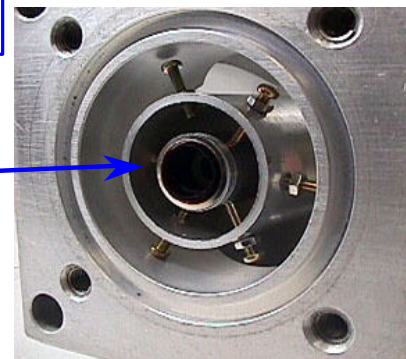
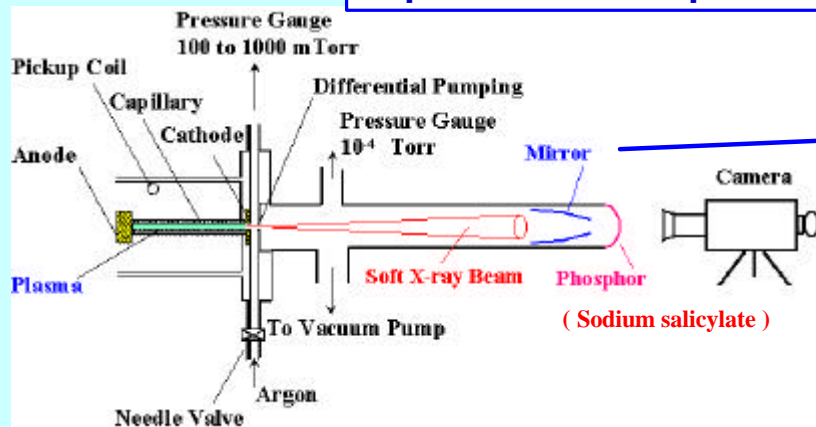
**Observed light spot of
the background light**
F-number=2.4,
Capillary length 160 mm.
Measured beam divergency:
14 mrad

**Device used for observation
of the divergence of
background light**

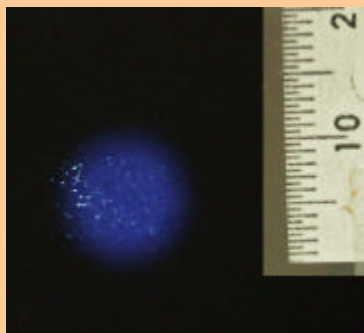


Focusing by Wolter Mirror

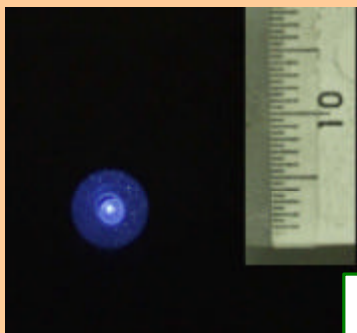
Experimental setup for SXR/EUV focusing



Experimental result



w/o mirror



with mirror

Dimension of the Wolter mirror

Walter type mirror condenses EUV light from a capillary discharge into a light spot of 1 mm diameter.

- **Ne-like Ar Soft X-ray Lasing was observed**
 - **Current of 9-32kA and half period of 110ns**
 - **Ceramic capillary : $d = 3, 4$ mm, $l = 150, 200, 350$ mm**
 - **Argon gas pressure : 150-800mTorr**
 - **Lasing at 46.9 nm was confirmed by spectroscopy**
 - **Maximum $gl = 4.3$ ($g = 0.27$ cm⁻¹) at 23.5 kA, 300 mTorr**
- **Sufficient pre-discharge current is essential for**
 - **Increase of laser output**
 - **Excess predischage current decreases the laser output instead of increasing**
- **Focusing of EUV light was confirmed**
 - **Using a Wolter type grazing incidence mirror, the beam image of 10 mm in diameter is condensed to a light spot of 1 mm.**

A scenic view of the Prague skyline at sunset, featuring the Vltava River, the Charles Bridge, and the Prague Castle. The sky is filled with soft, colorful clouds in shades of orange, pink, and blue. The city's architecture, including red-tiled roofs and historic buildings, is visible in the background. A stone bridge railing and a traditional street lamp are in the foreground on the left.

Dekuju vám

Thank you